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## **Tools for Climate Change Adaptation: Intelligent Control of Green Infrastructure**



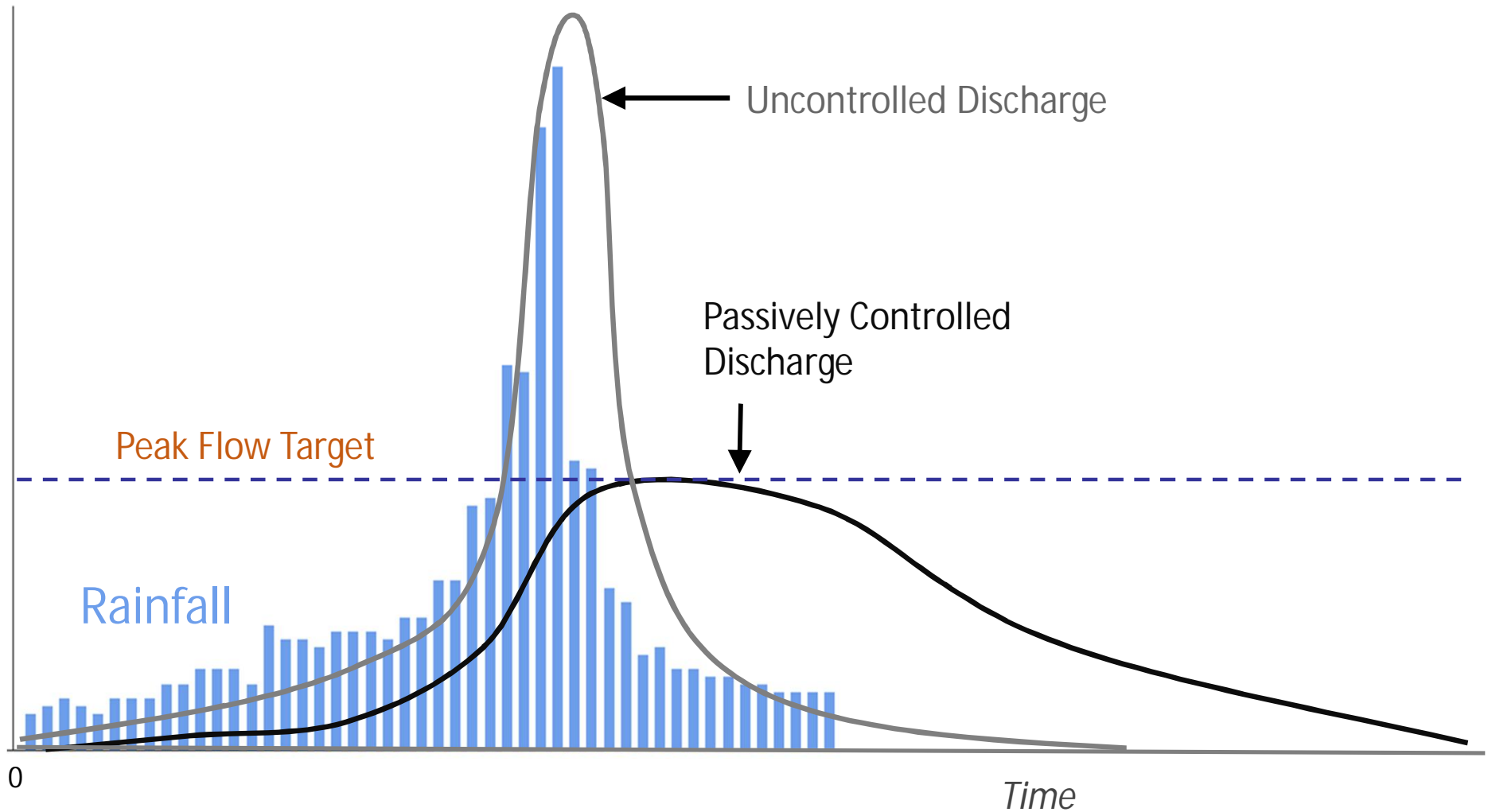
**Daniel Bourdeau, PE, CPESC, CPSWQ  
Senior Engineer**

**NEWEA 2016 Annual Conference and Exhibit  
January 27, 2016**

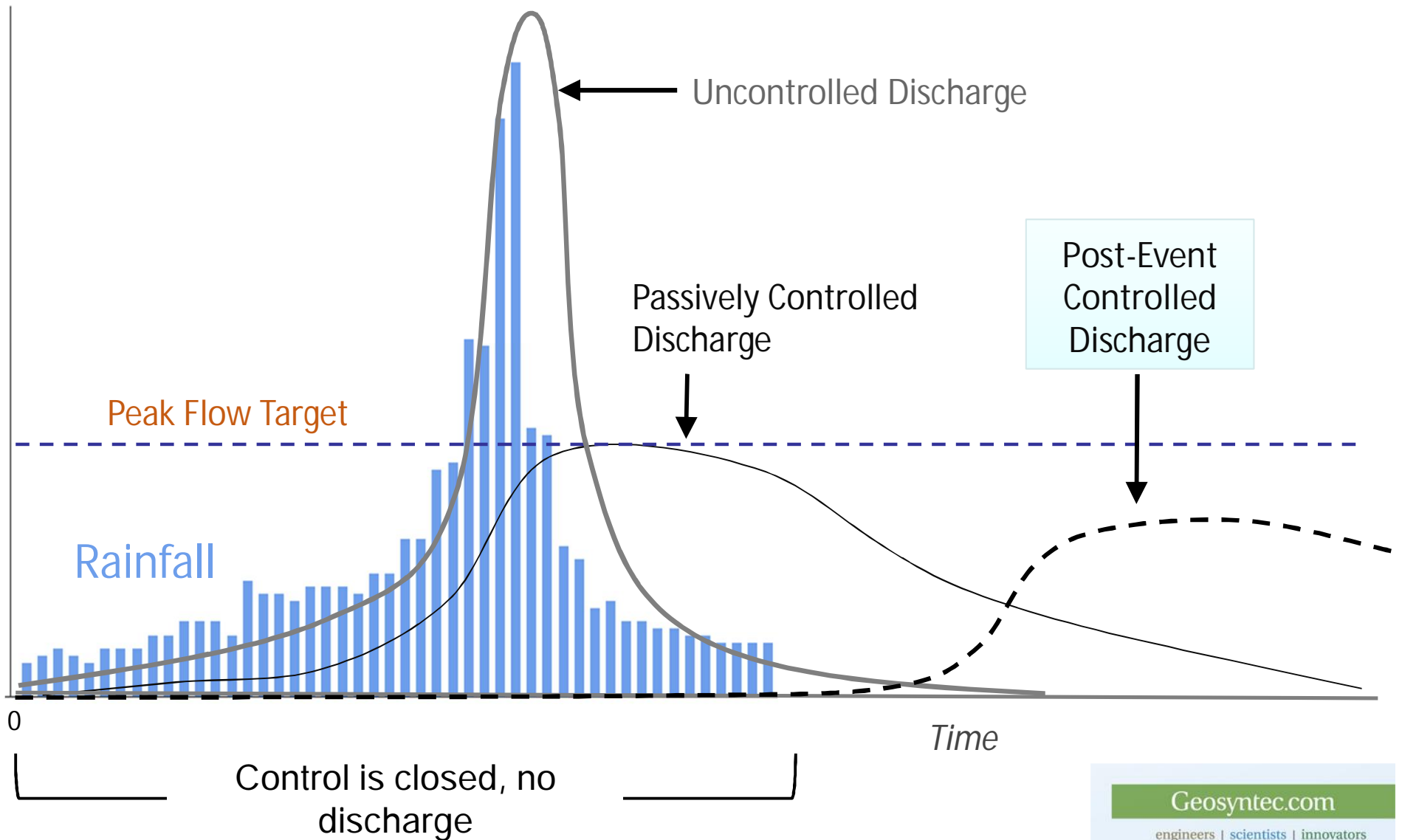
## Outline

- *Passive and Active Stormwater Management*
- *Real-Time Controls and Monitoring*
- *GI Applications and Performance Results*

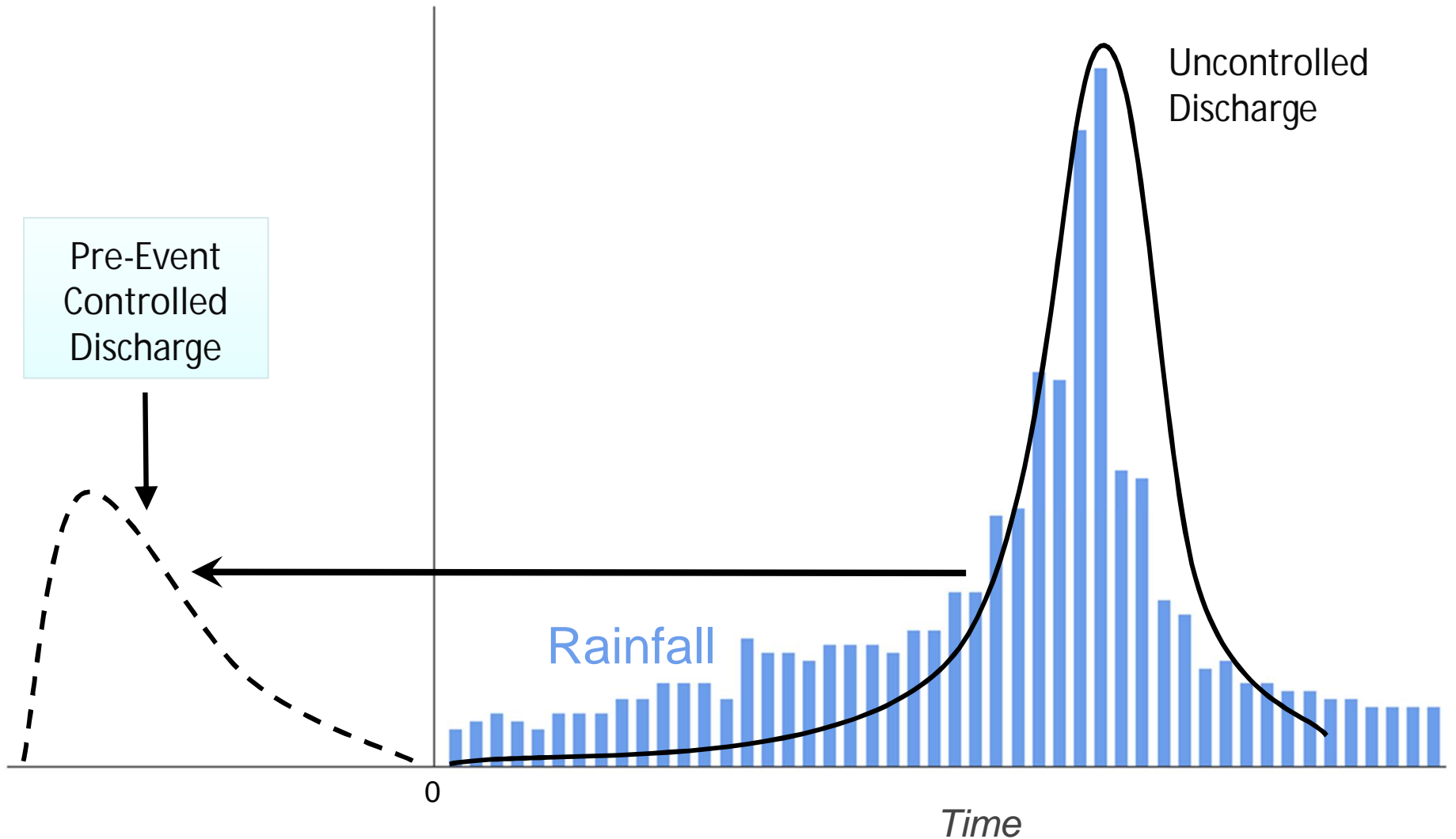
# Passive Stormwater Control



# Active Stormwater Control



# Active Stormwater Control

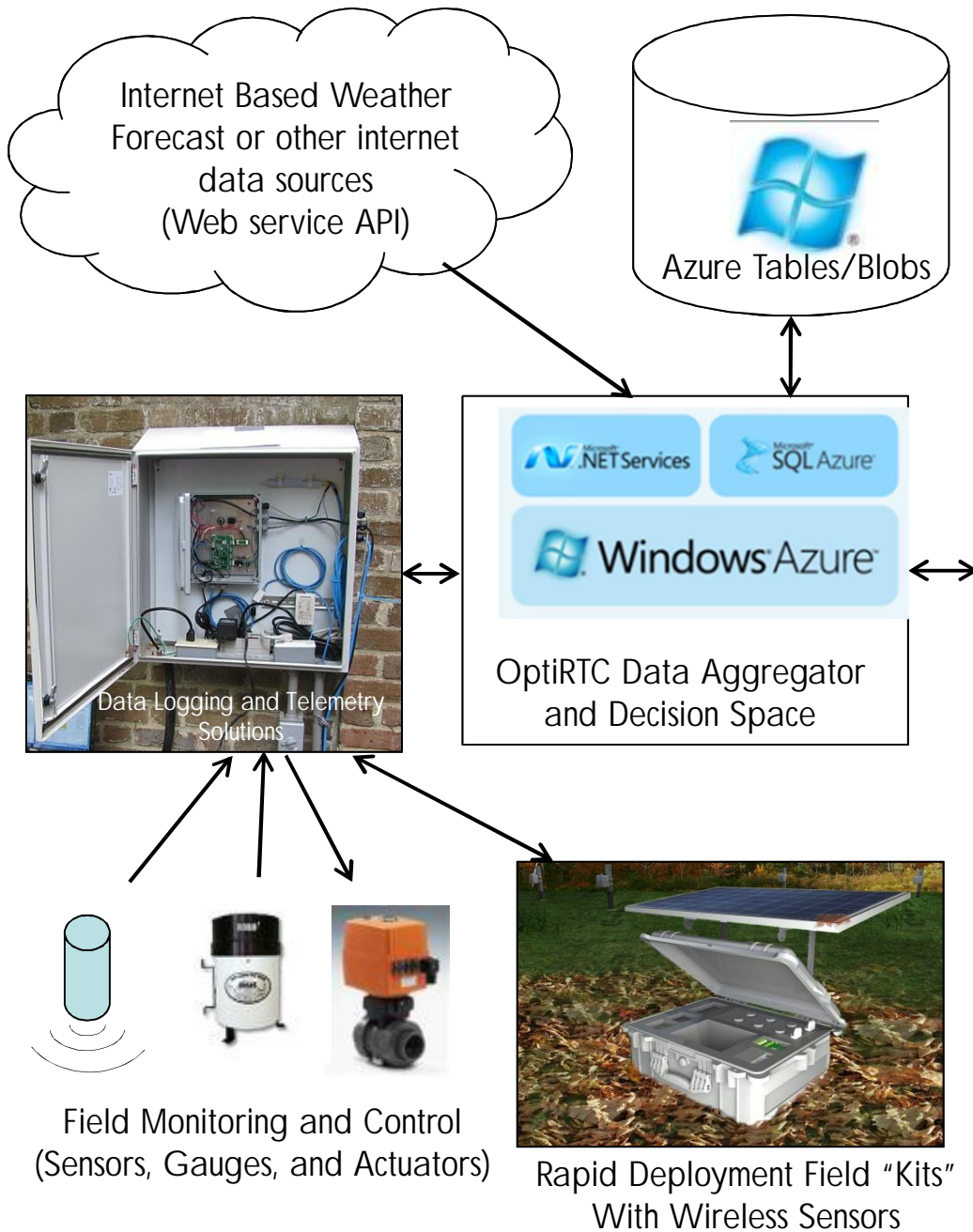


# Active Control System – OptiRTC

A cloud-based suite of computing services that provides automated real-time control and data management solutions for a wide range of environmental applications.



# Platform Overview



**User Interface Web Services and User Dashboards**

Microsoft Silverlight

The user interface consists of several dashboards. The top row shows a dashboard with multiple charts and a map of the United States. The middle row shows a "Water Quality Stations" dashboard with multiple line graphs. The bottom row shows a "Oak Hill - OPR" dashboard with multiple line graphs and a satellite map. Below the dashboards, there is a list of notification methods: Alerts, Email, Tweet, SMS, and Voice Autodial. To the right of this list are two mobile phones displaying weather maps.

# Smart System Control Logic

## If X then Y

- If a storm is predicted → open valve
  - This will lower water surface elevation in system during **dry weather**
- When the rain begins → close valve
  - This will hold water in the system during **wet weather**
- Otherwise retain water level in system to:
  - ...hold water for potable reuse
  - ...maximize infiltration
  - ...maximize water quality



## Technology Applications

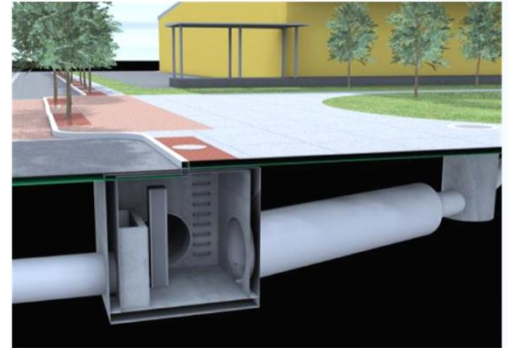
- Advanced rainwater harvesting
- Retention and detention systems
- Controlled underdrain bioretention
- Active porous pavement systems
- Active blue and green roofs



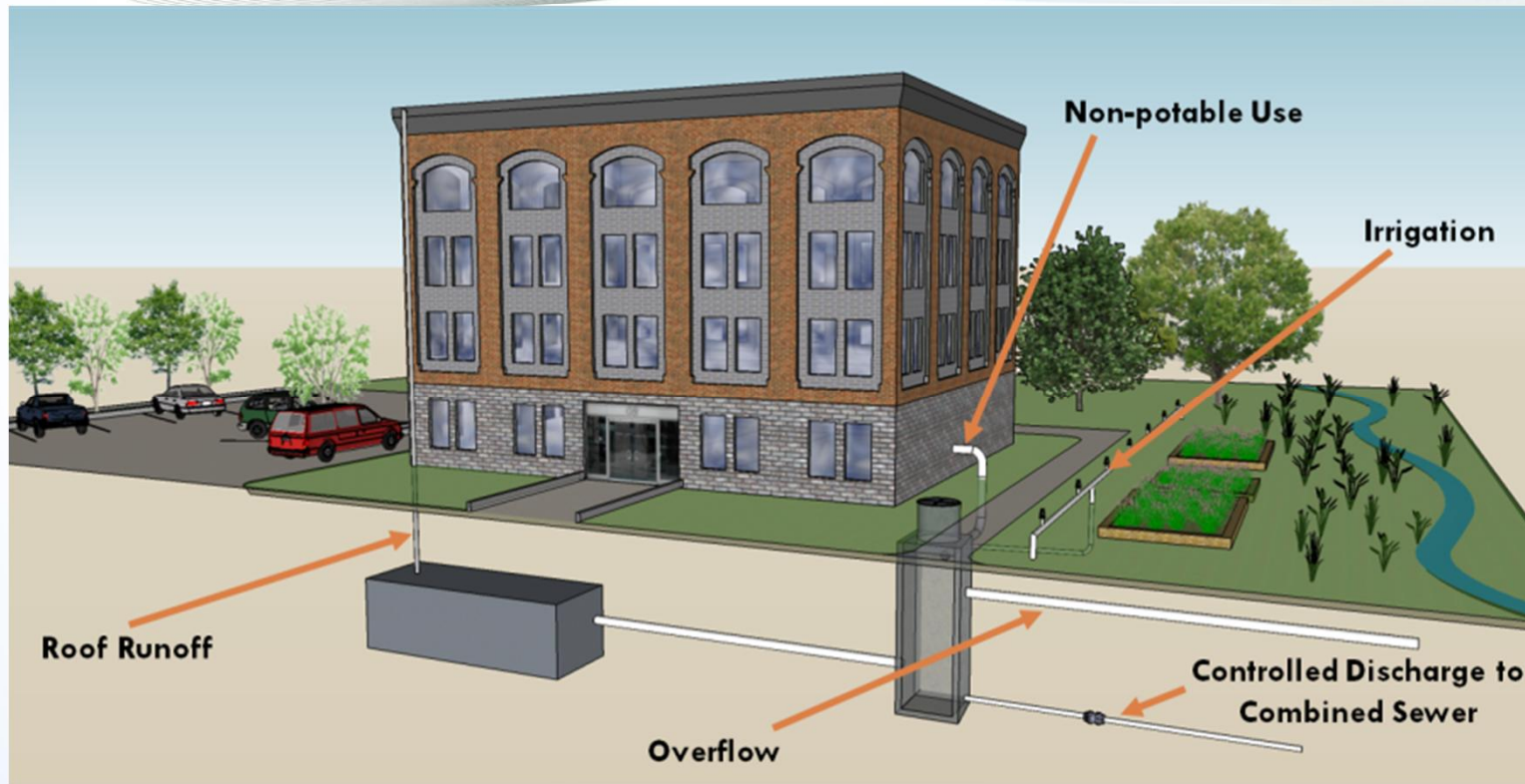
# Technology Application: Advanced Rainwater Harvesting

# Smart Stormwater Control

- Advanced rainwater harvesting
- Predictive retention and detention systems using precipitation forecasts



# Advanced Rainwater Harvesting System Concept



Goal: Storage for both effective wet weather control and on-site use

# Advanced Rainwater Harvesting System Conowingo Elementary School

## System Description

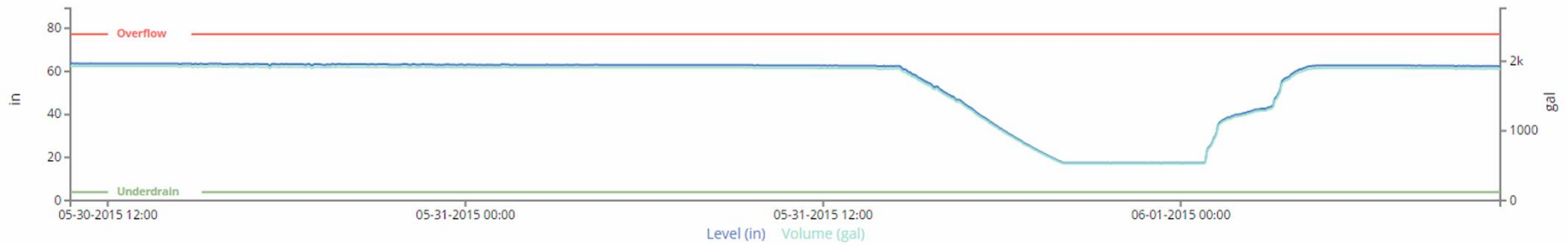
- Cistern installed to store runoff and make available on-site
- Web-based precipitation forecasts are used to automatically control releases to downstream BMPs (e.g., infiltration/bioretention) or MS4



# Conowingo ARH – Dashboard System Behavior Week of 5/30/2015

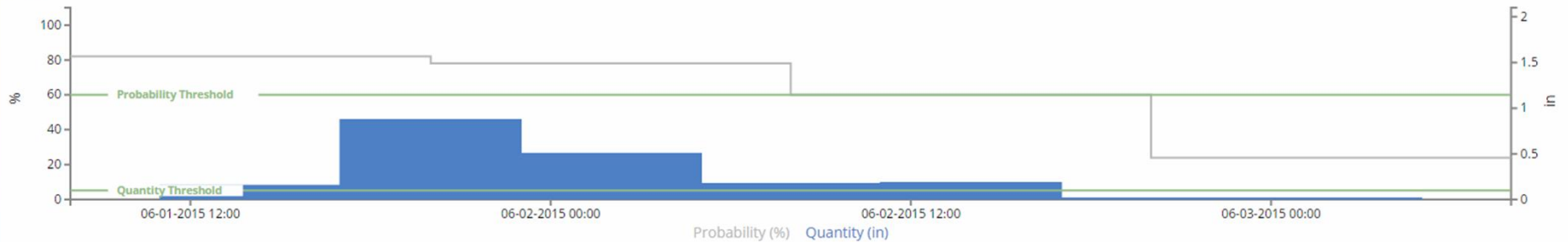
## Cistern Level and Volume

12hr | 24hr | **48hr** | 1wk



## Precipitation Forecast

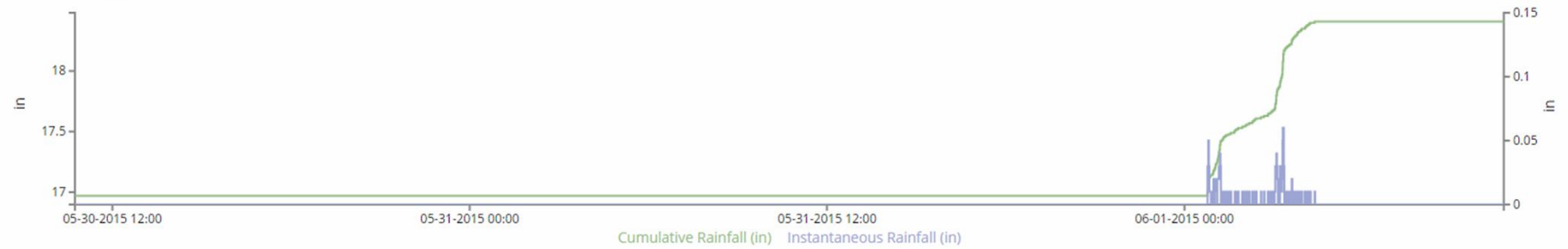
(48hr)



# Conowingo ARH – Dashboard System Behavior Week of 5/30/2015

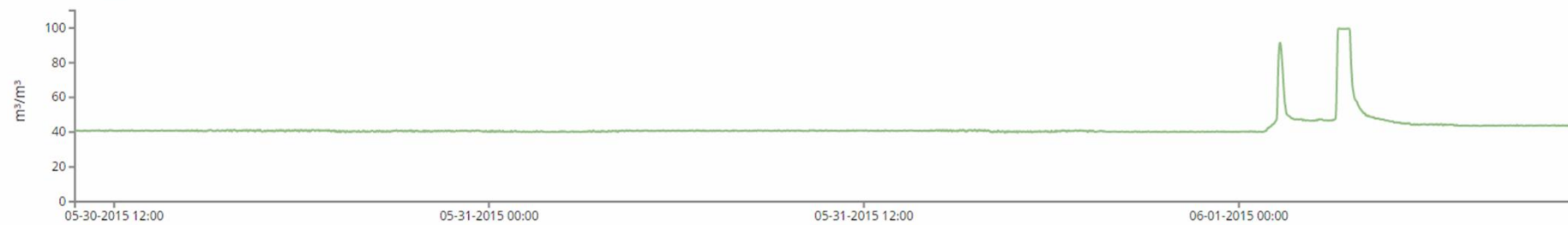
## Rainfall

12hr | 24hr | **48hr** | 1wk



## Butterfly Garden

12hr | 24hr | **48hr** | 1wk



WORKING FOR WATER QUALITY



# How much of a difference can these systems make??

Advanced Rainwater Harvesting System from NC State install:

	<b>Active System</b>	<b>Passive System</b>
Overall Wet Weather Volume Reduction	86%	21%
Mean Peak Flow Reduction	93%	11%
Overflow Frequency	18%	58%

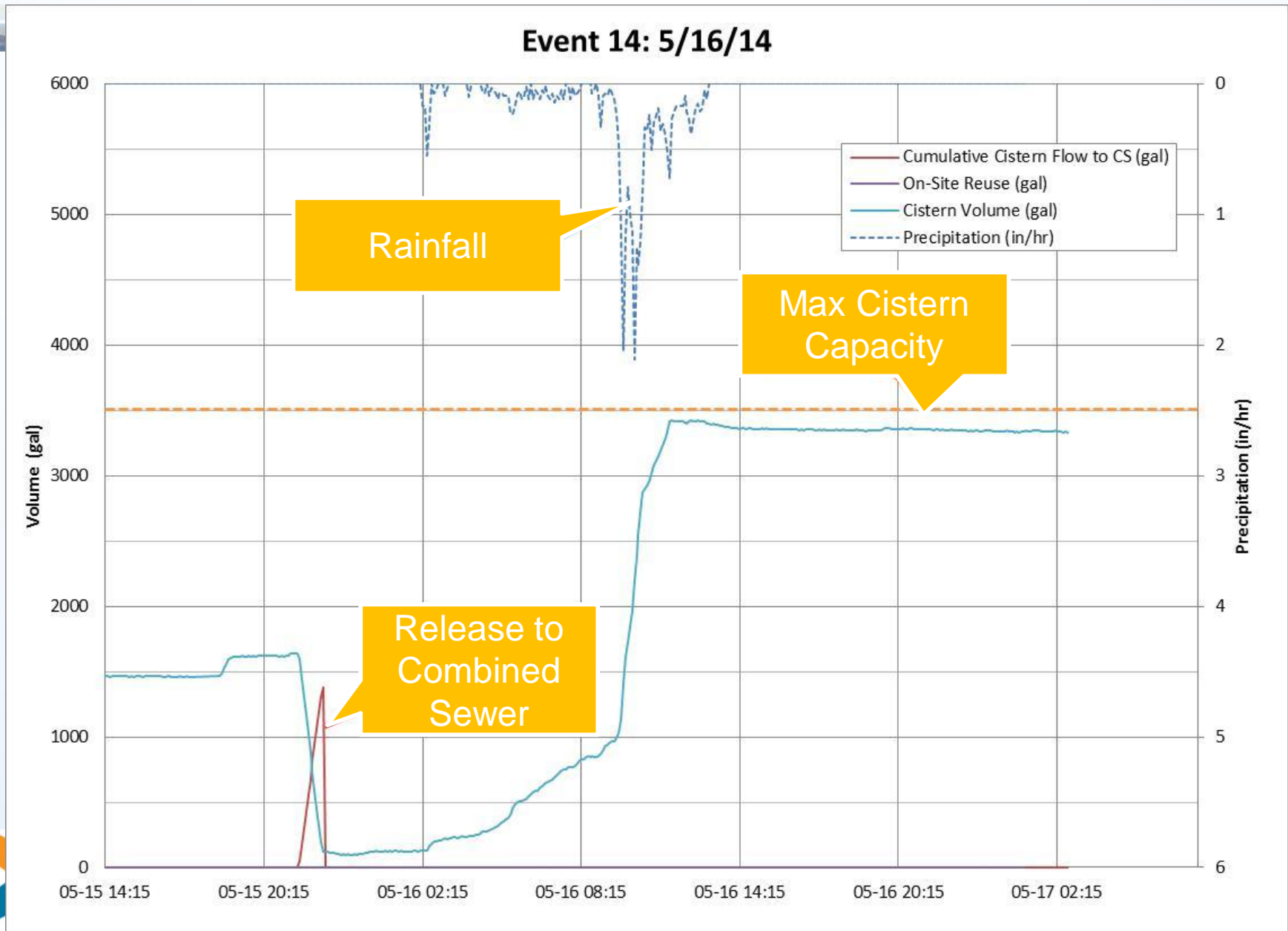
\*DeBusk, 2013



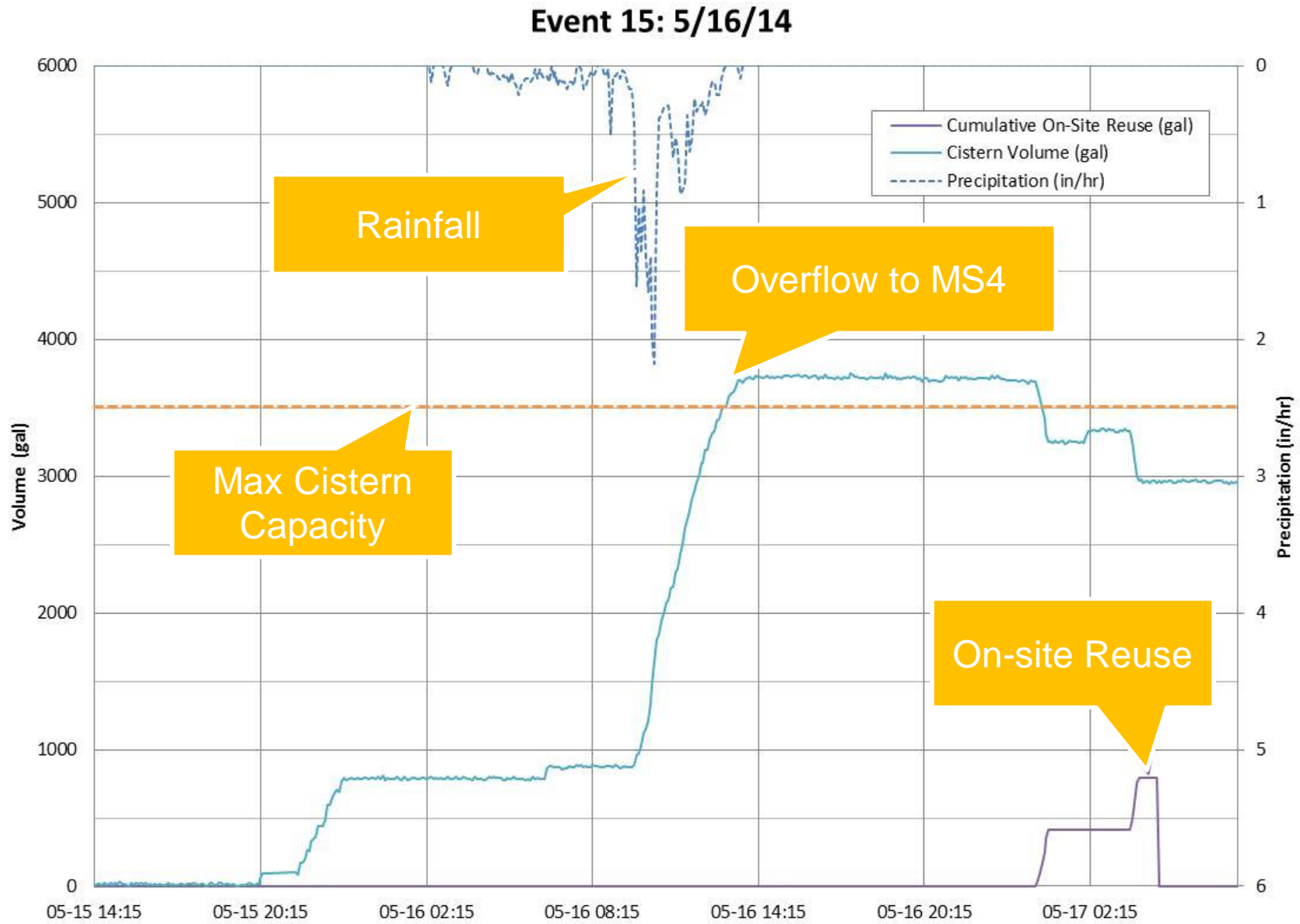
# DC Firehouse – Active Cisterns



# Advanced Rainwater Harvesting: EH #3



# Advanced Rainwater Harvesting: EH #25



# Technology Application: Smart Detention/Retention/Flood Control Retrofits

# Brooklyn Botanical Garden – Smart Control for CSO Mitigation

Water Level Sensor



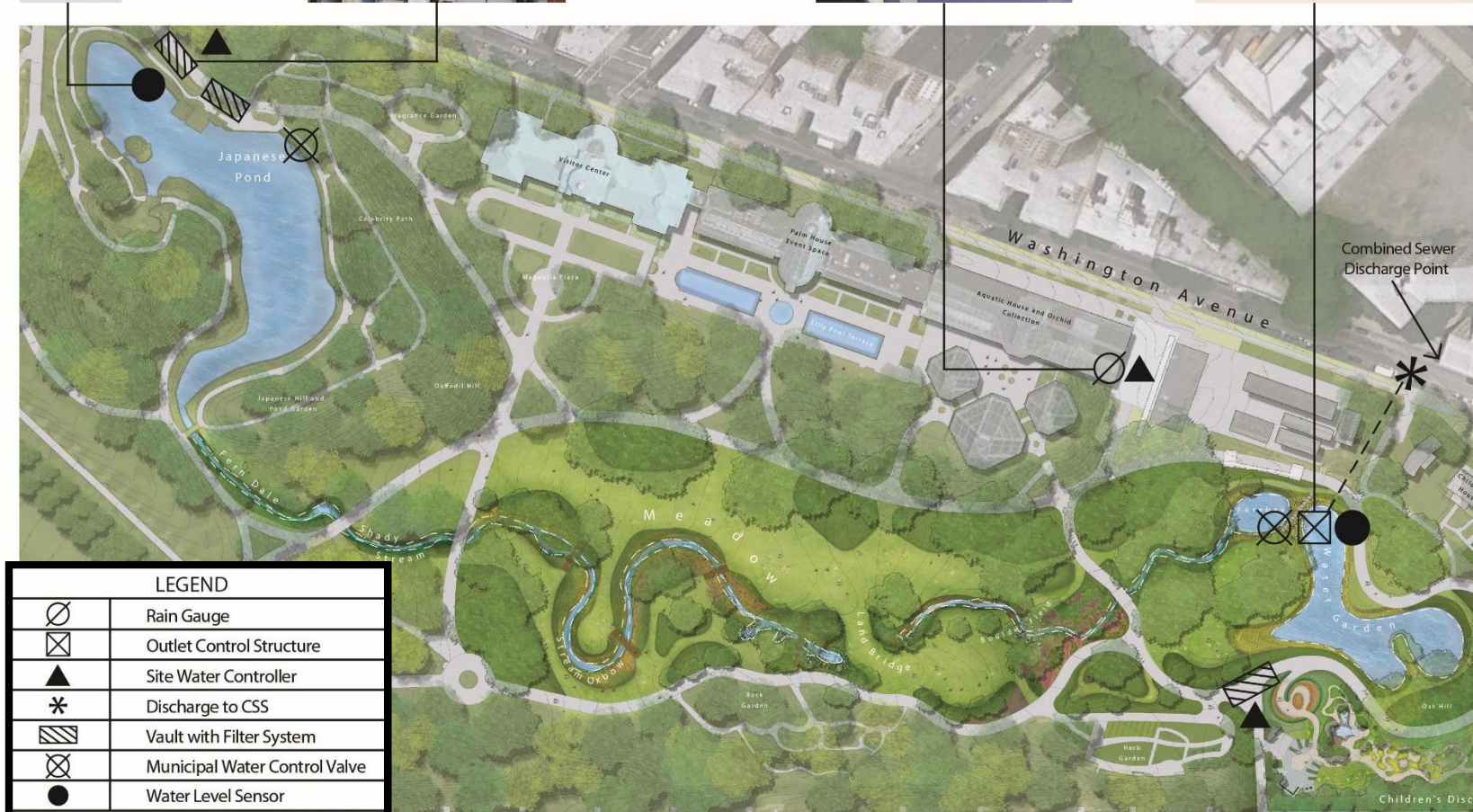
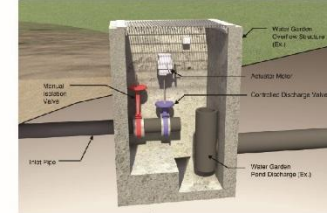
Site Water Controller



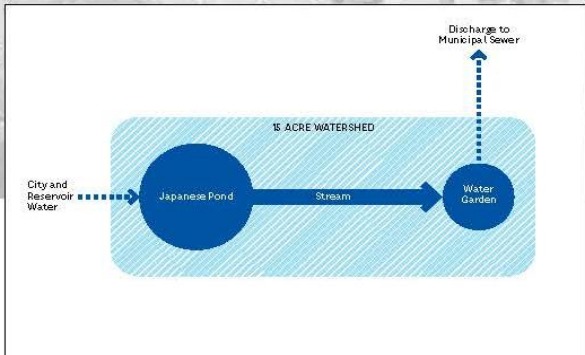
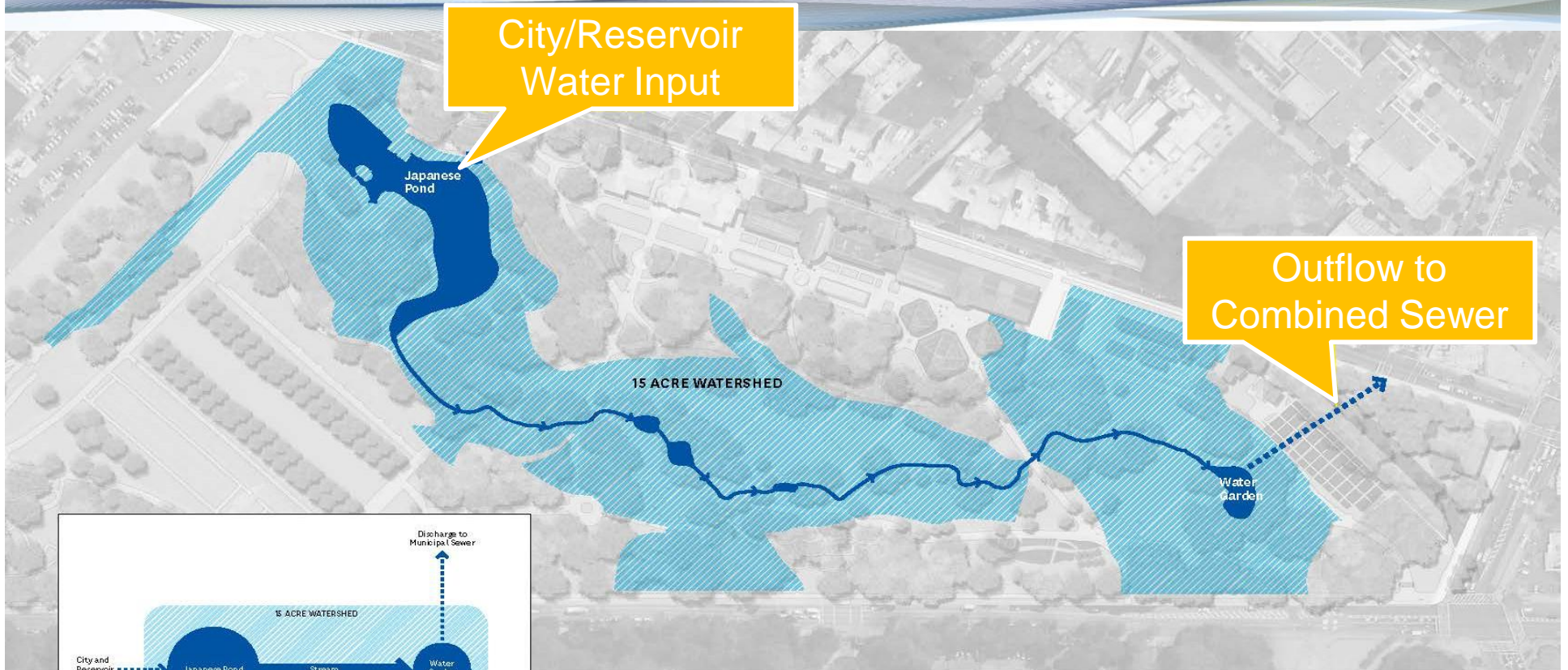
Tipping Bucket Rain Gauge



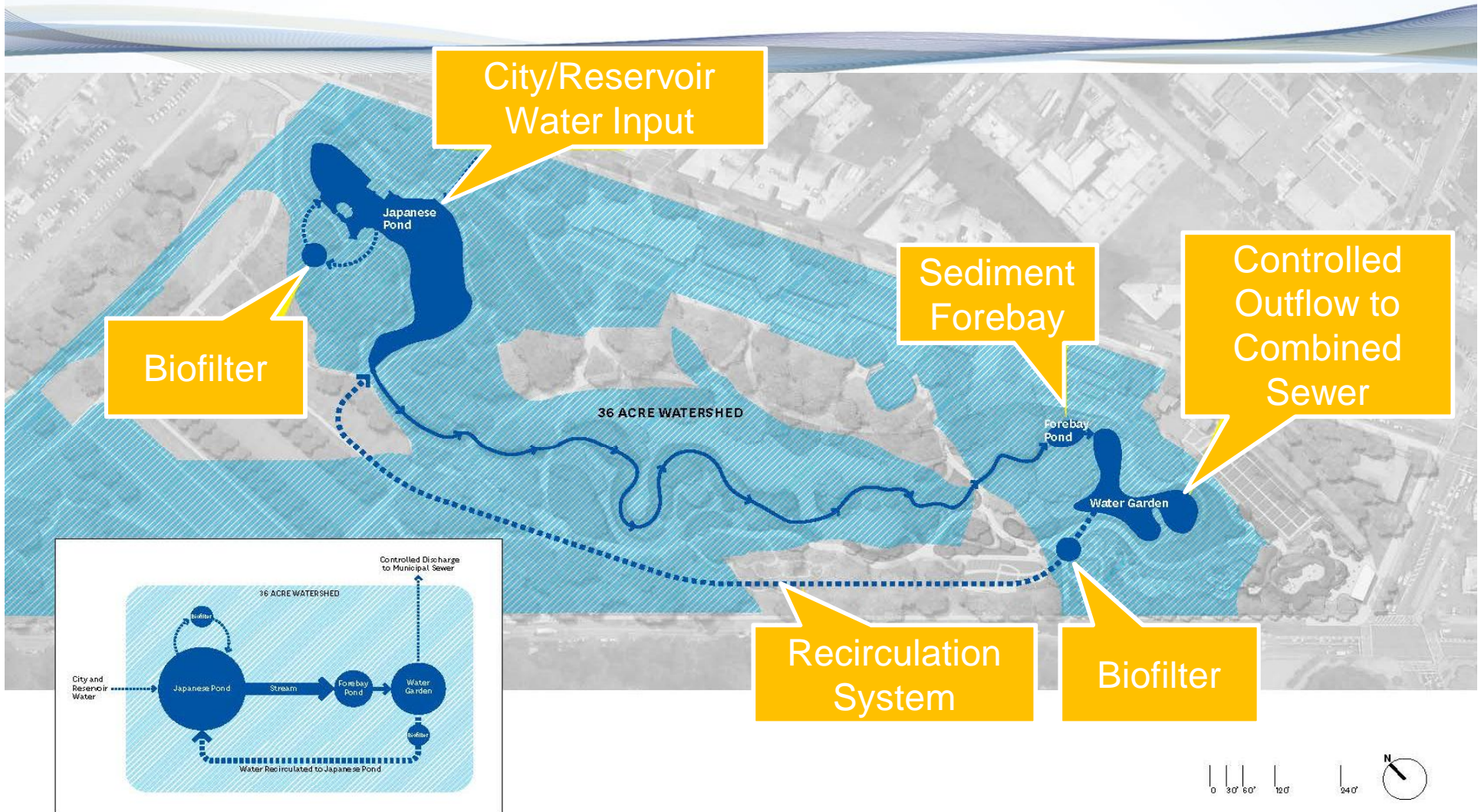
Water Garden Outlet Control Structure



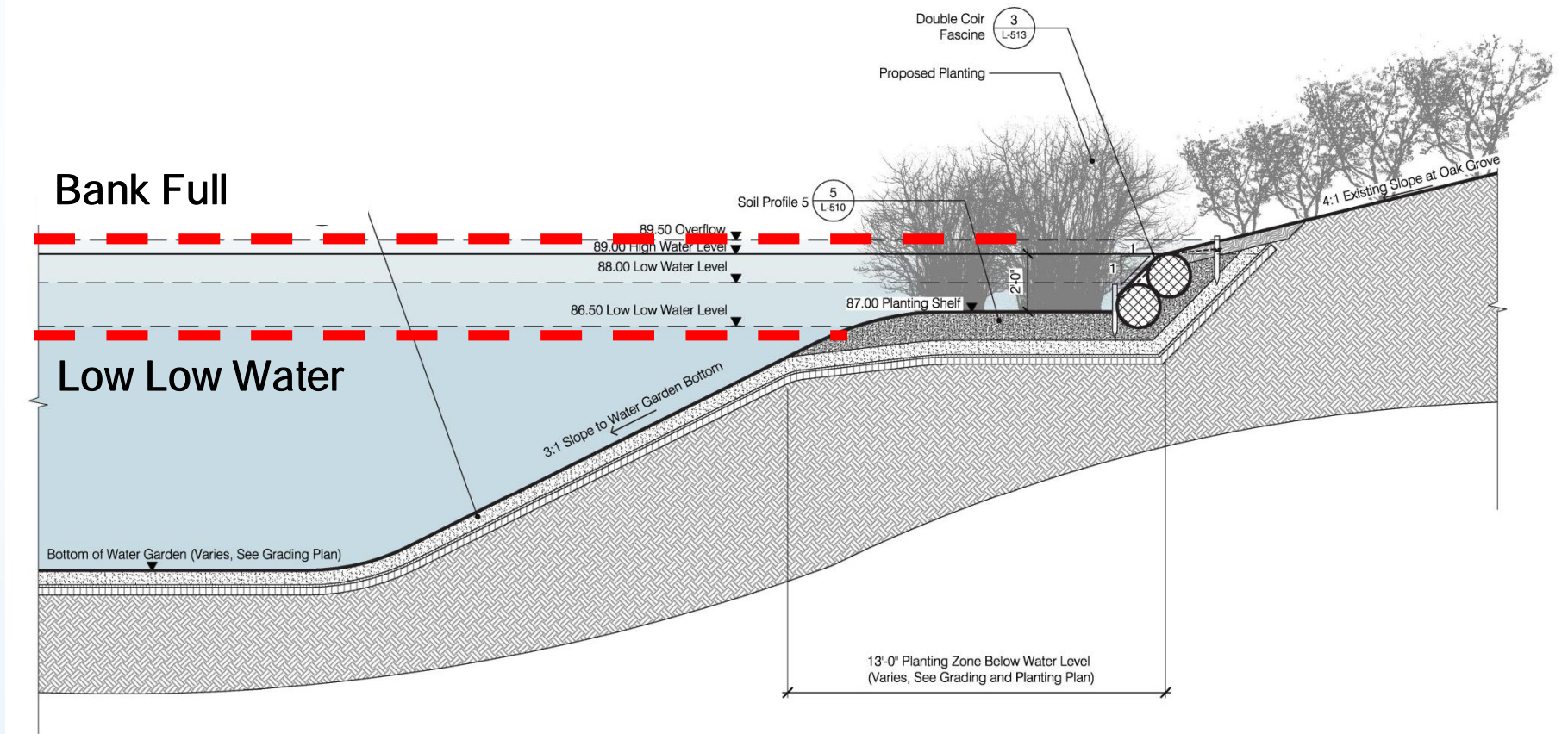
# Existing Water Circulation System



# Proposed Water Recirculation System



# Water Garden: Water Level Control

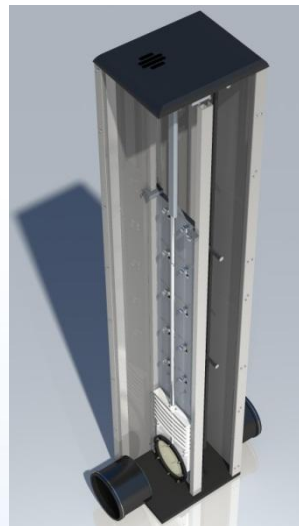
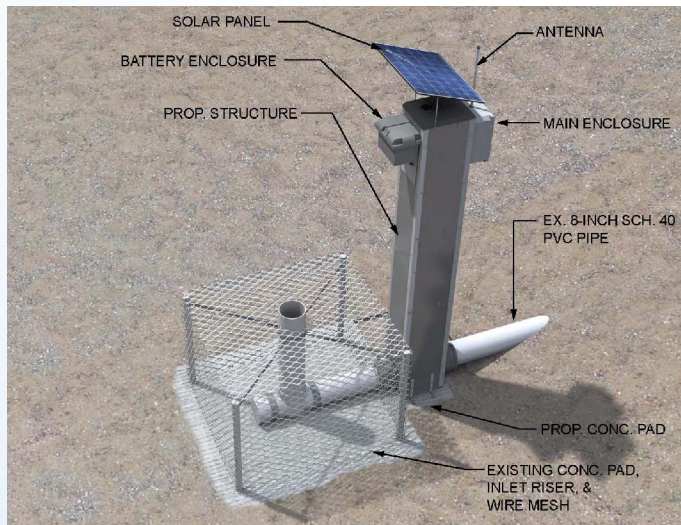


Maximize volume available for stormwater storage



# Pond/Flood Control Retrofit

- Outlet Control Structure Retrofit for Water Quality Enhancement
- Balance Flood Control and Water Quality



# Technology Application: Controlled Underdrain Bioretention

# Controlled Bioretention Underdrain

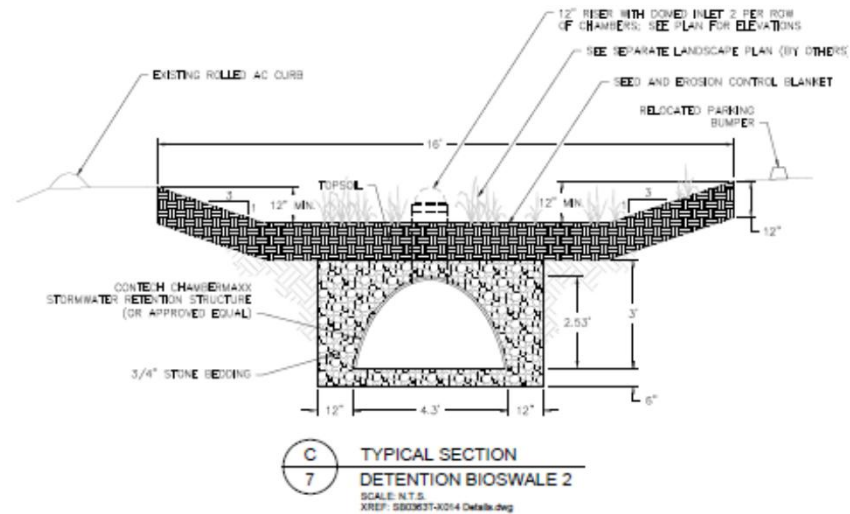


Bioretention site rendering



Maximize Infiltration, minimize bypass, and achieve water quality targets

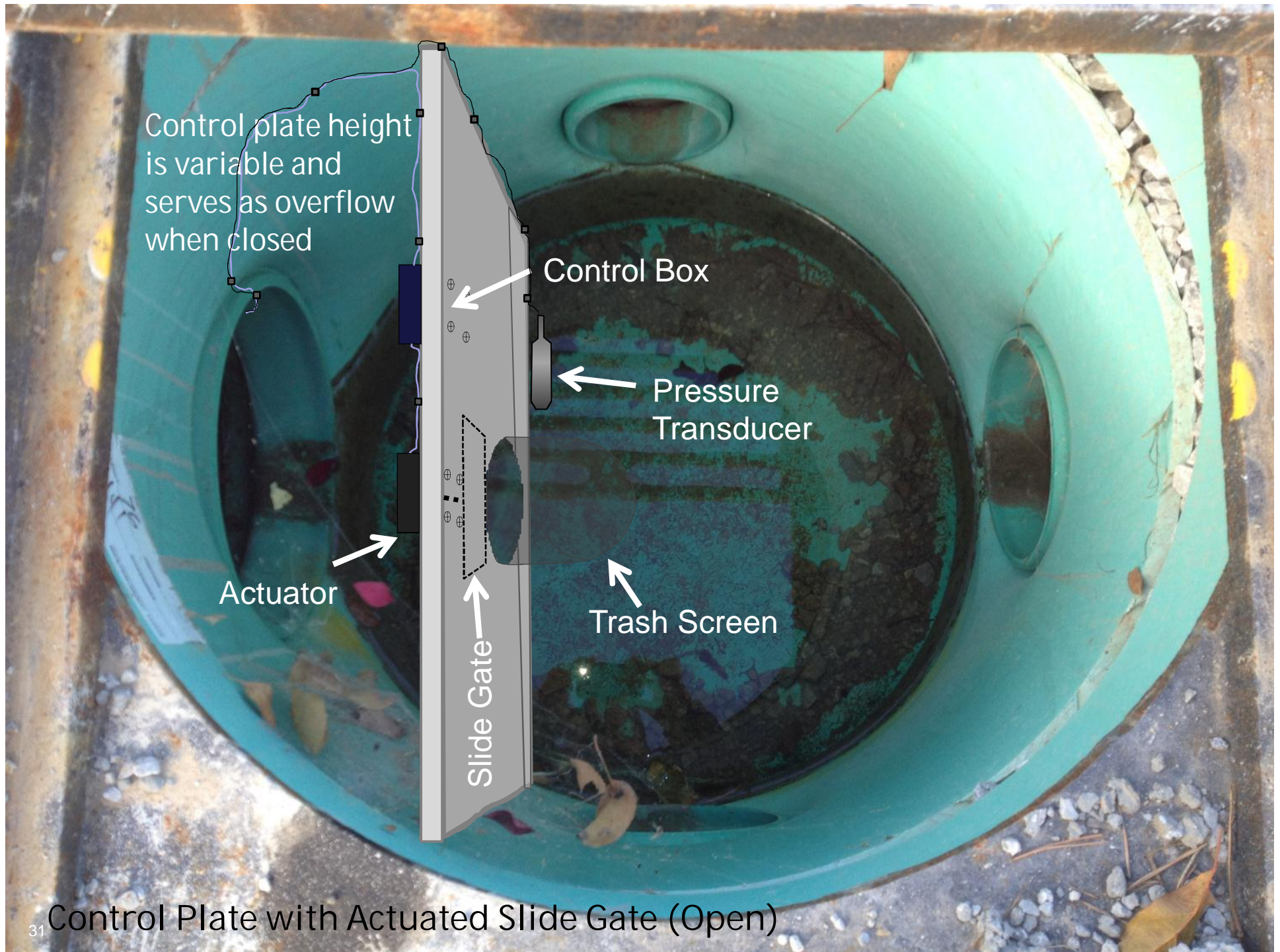
## Controlled bioretention Underdrain



# Technology Application: Active Porous Pavement

# Actively Controlled Porous Pavement City of Omaha, NE

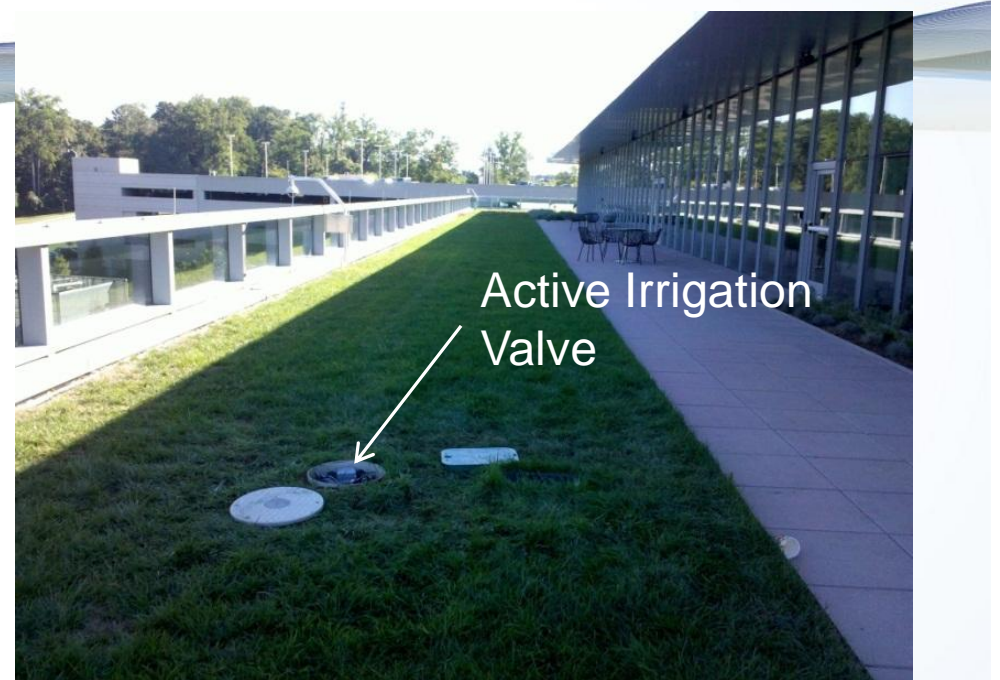




# Technology Application: Active Green Roofs and Blue Roofs



# Active Green Roof, Pennsylvania



Green Roof Project Site





SAP HQ, Green Roof

Navigate to..

Executive

Map

Admin

Tools

Sign Out

### Recent Status

#### Liquid Level Sensor

Above Sensor 2%, Below Sensor 98%  
Past 24 Hours



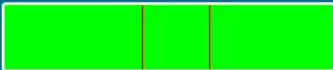
#### Irrigation Valve

Valve Closed 77%, Valve Open 23%  
Past 24 Hours



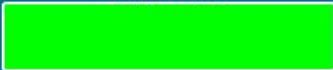
#### Local Network

Offline 1%, Online 99%  
Past 24 Hours



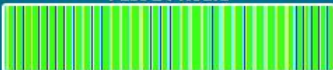
#### Automation Mode

Manual 0%, Automatic 100%  
Past 24 Hours



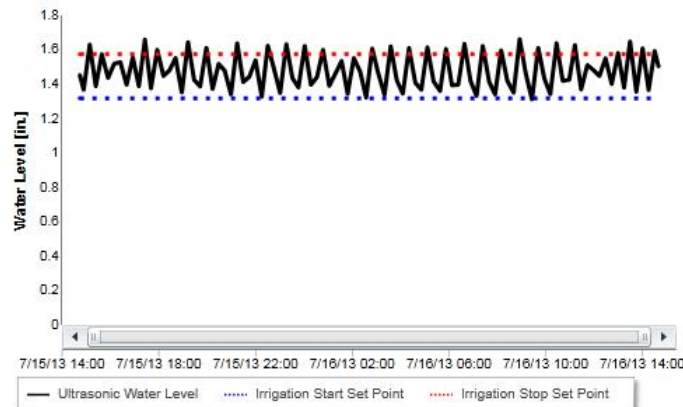
#### Controller State

DATING-OPEN 13%, HOLD-OPEN 9%,  
Past 24 Hours



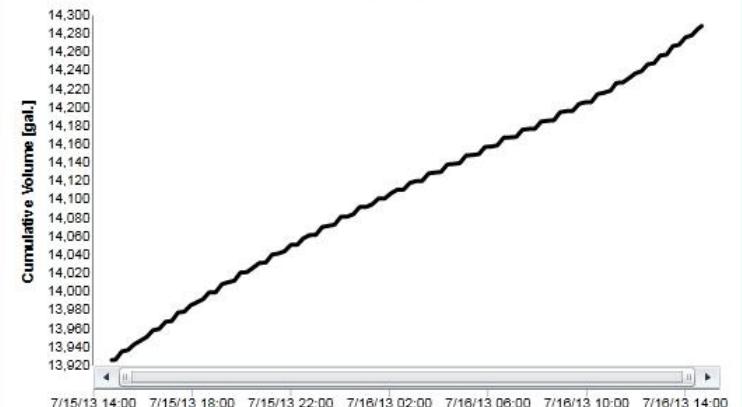
### Green Roof Operations

chart tools Past 24 Hours. Latest record at 7/16/2013 2:41:40 PM export | dates..



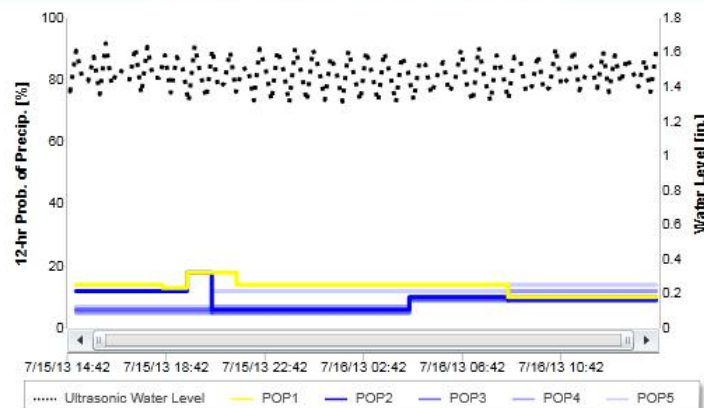
### Irrigation Consumption Meter

chart tools Past 24 Hours. Latest record at 7/16/2013 2:41:40 PM export | dates..



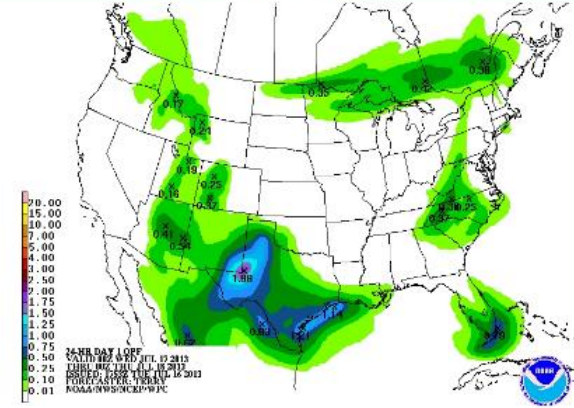
### Forecast Time Series

chart tools Past 24 Hours. Latest record at 7/16/2013 2:41:40 PM export | dates..



### US NOAA Image

24 Hour Forecast



# Dashboard SAP Green Roof



SAP HQ, Green Roof

Navigate to..

Executive

Map

Admin

Tools

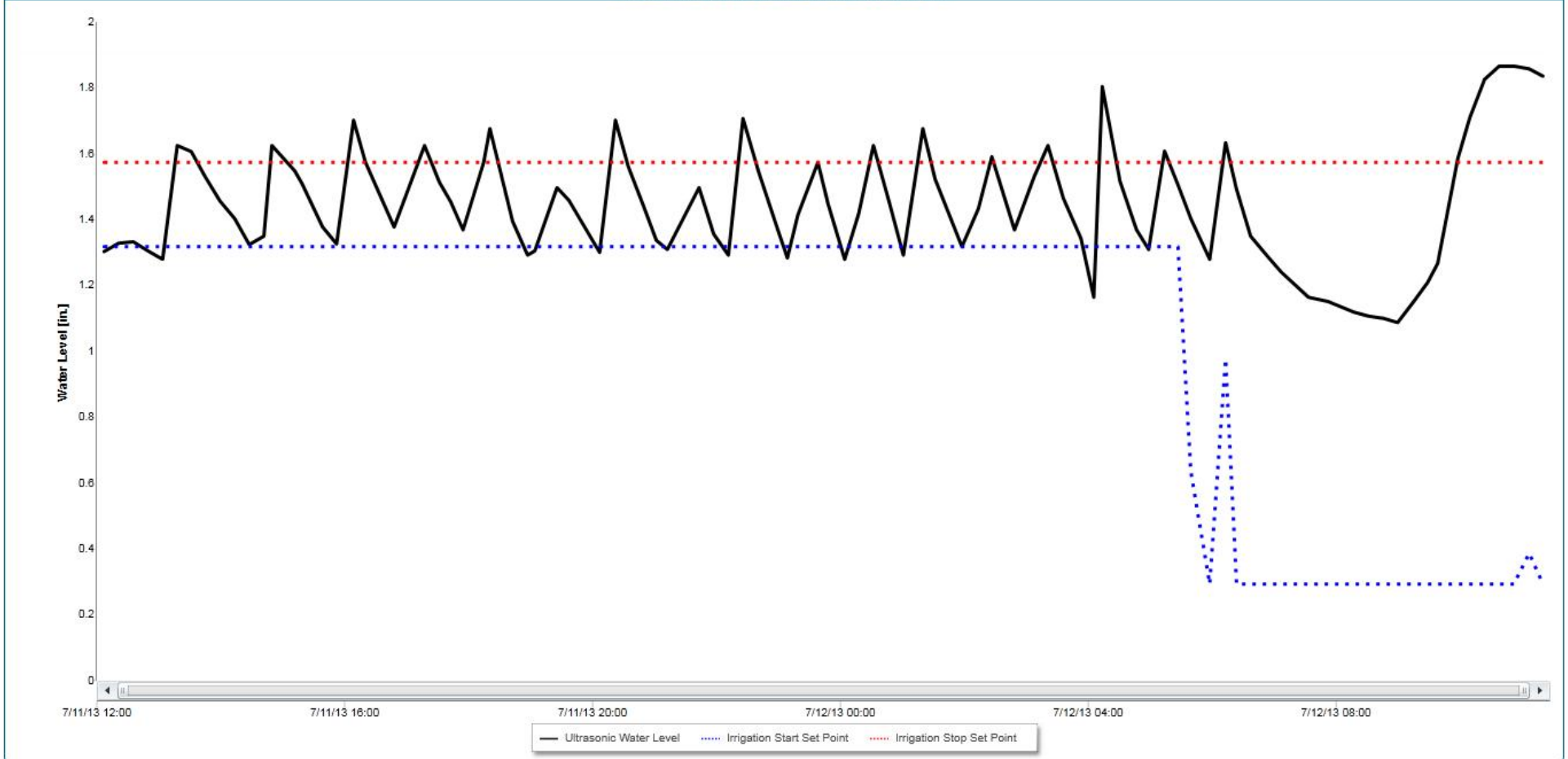
Sign Out

chart tools

Green Roof Operations

Past 24 Hours. Latest record at 7/12/2013 11:26:47 AM

export | dates..



# Summary and Closing Thoughts

- Smart systems provide the opportunity to:
  - ...to control the way **systems function based on the event it is managing** at any given time
  - ...to change the ways we are managing stormwater in real-time – which may become **more important for climate change resiliency**
  - ...to implement **low cost retrofits** on existing infrastructure for improved performance
  - ...to use low cost, reliable, and highly functional sensors and sensor platforms to **ensure systems are functioning as designed** and to **inform maintenance on GI systems**

*Thank You NEWEA!*